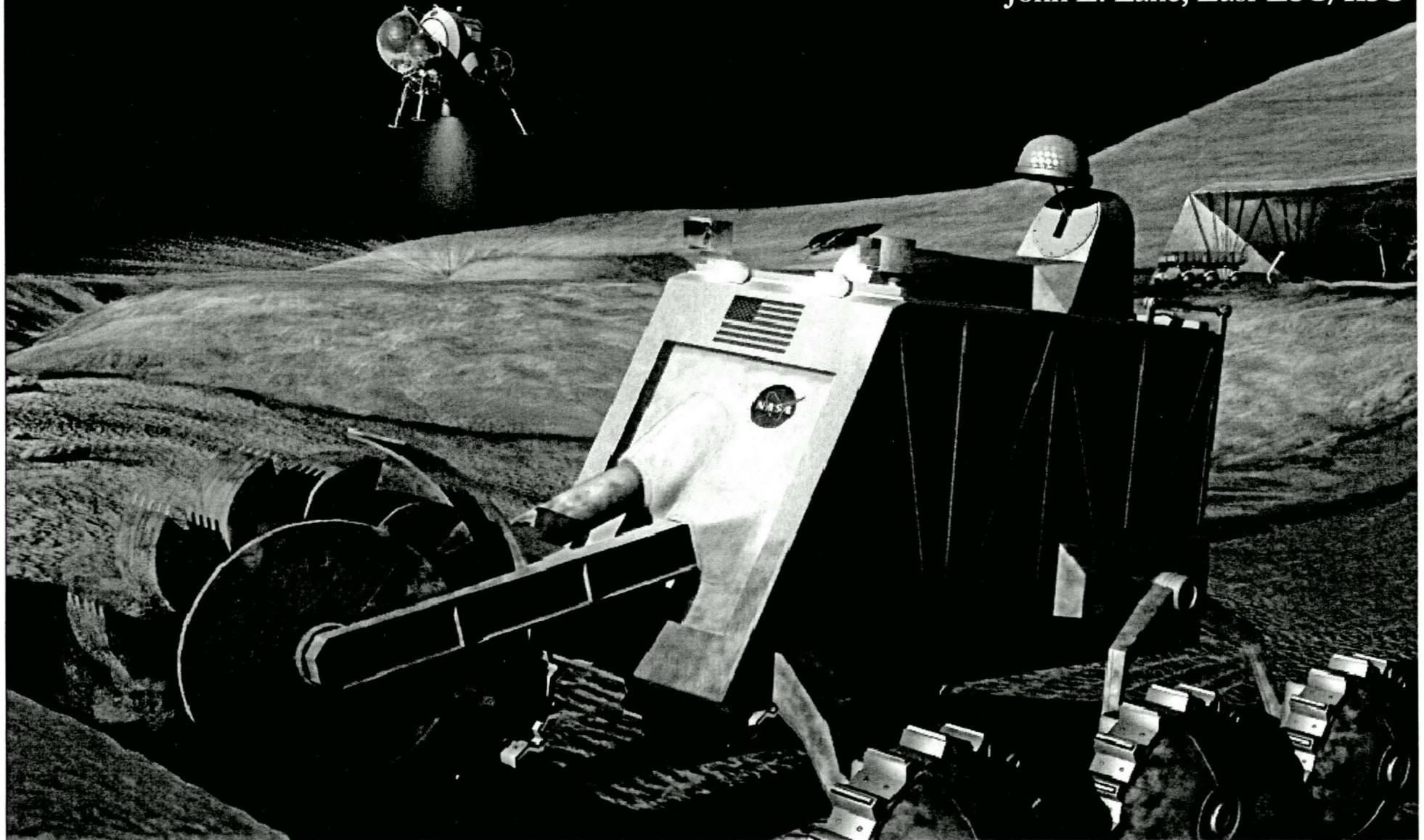


Lunar Rocket Exhaust Phenomenology Indicates that Plume/Soil Models are Too Simple

Philip Metzger, NASA/KSC
John E. Lane, Easi-ESC/KSC



Outline

- Background
- Phenomenology on Mauna Kea
- Phenomenology on the Moon
- What is Needed

Background

Different Effects in Different Environments



Earth



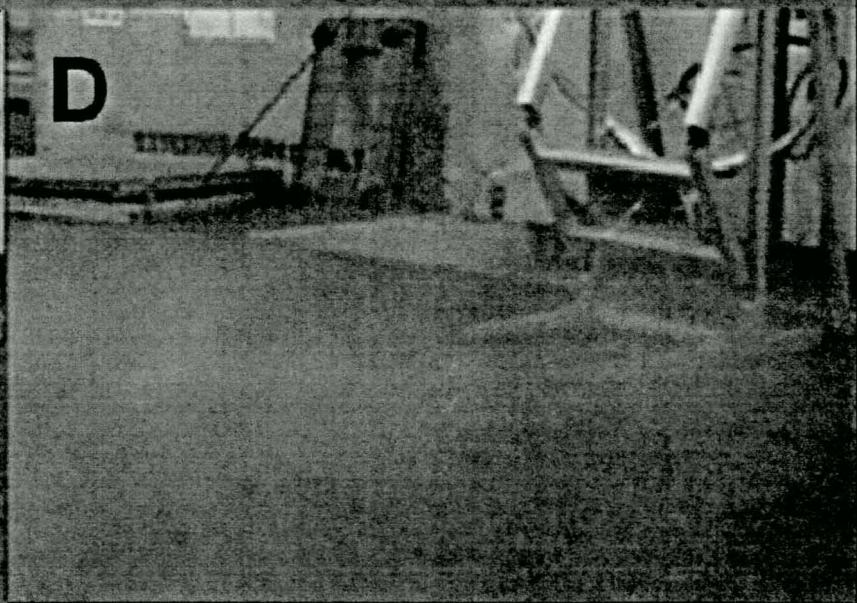
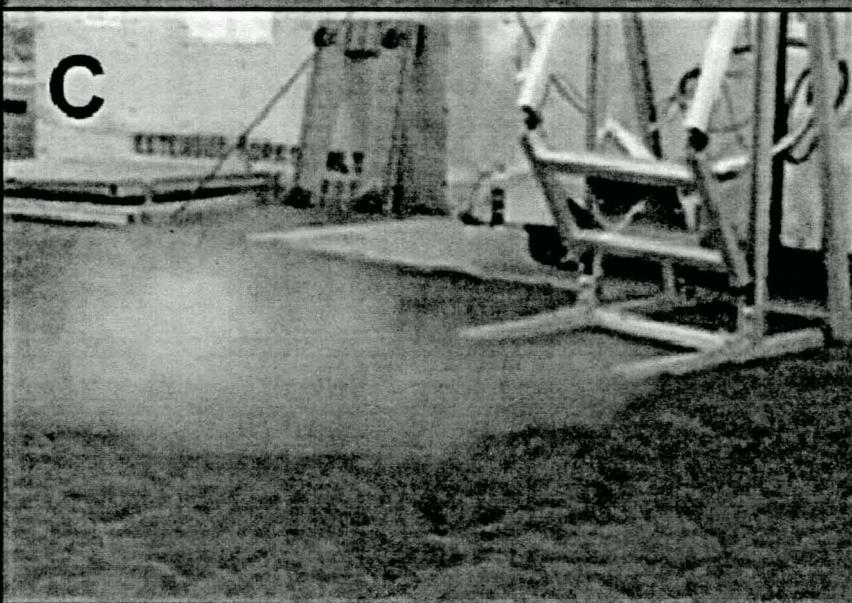
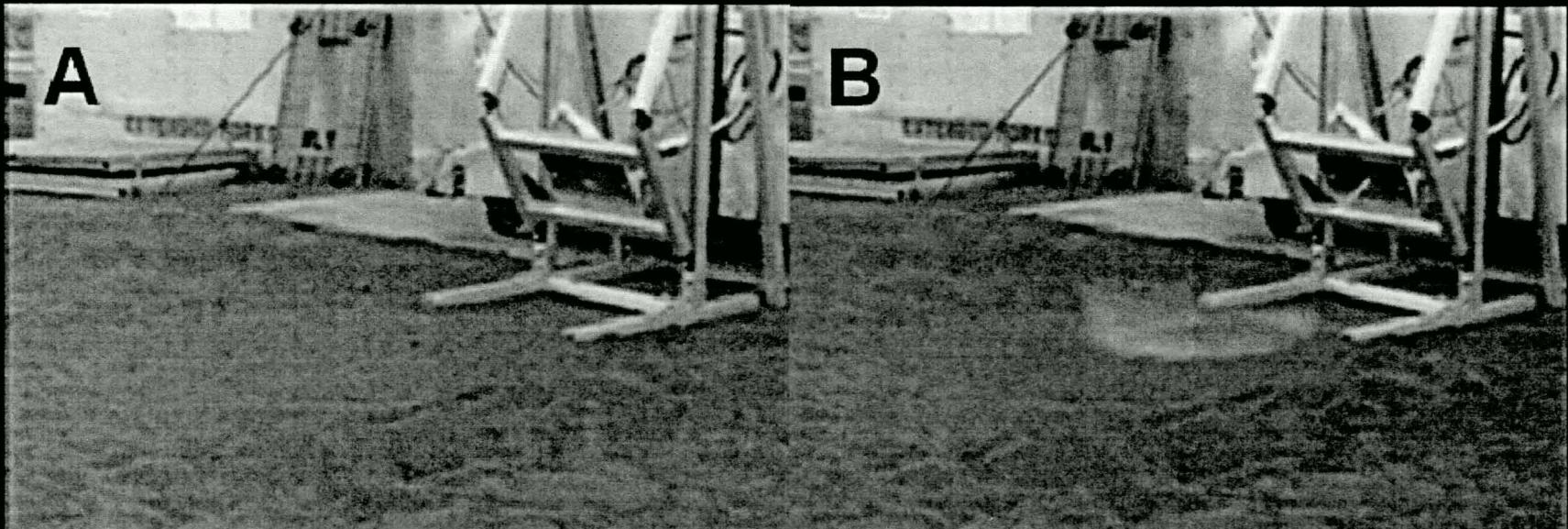
Mars



Moon

Phenomenology on Mauna Kea

Four Stages



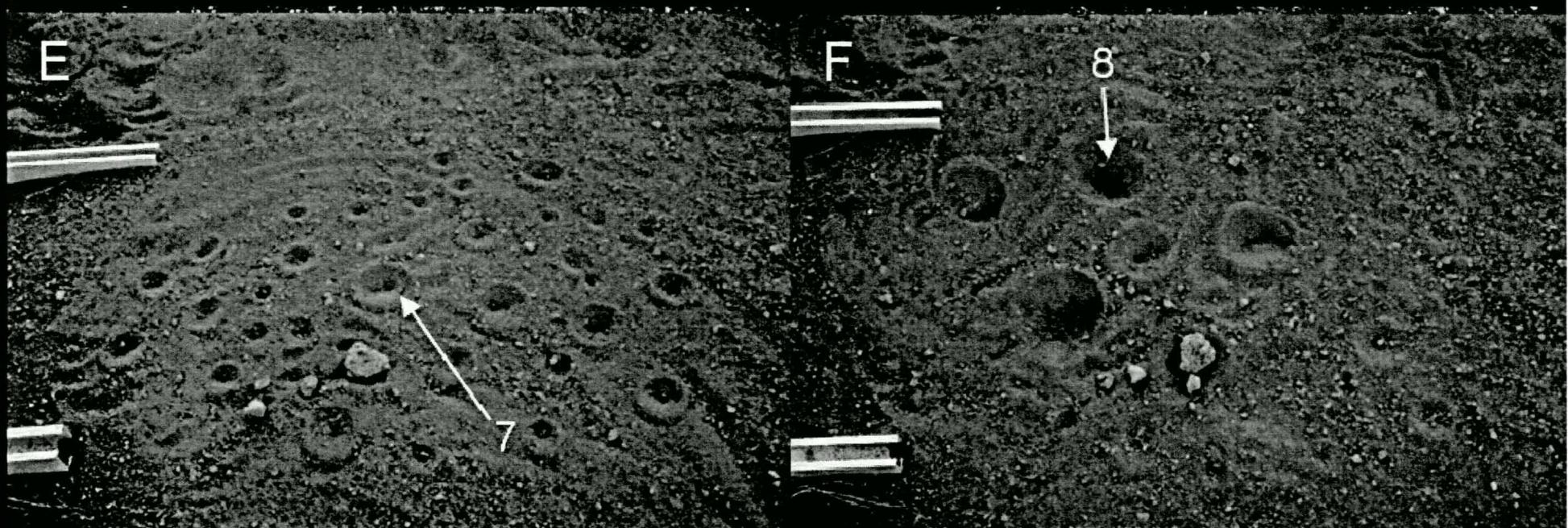
A

B

C

D

Surface Before Impingement



Show video

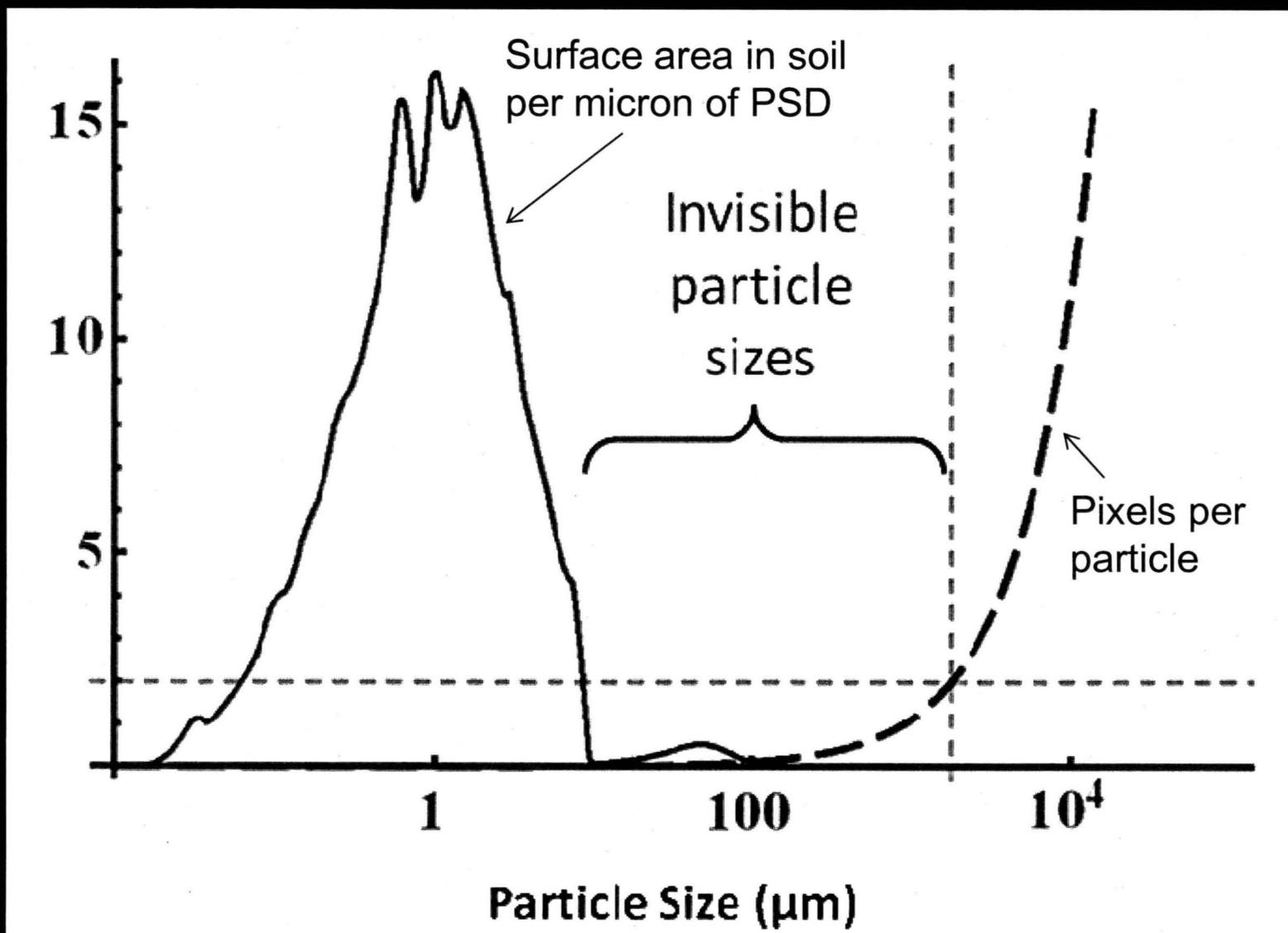
Discuss rolling transport

Dust release

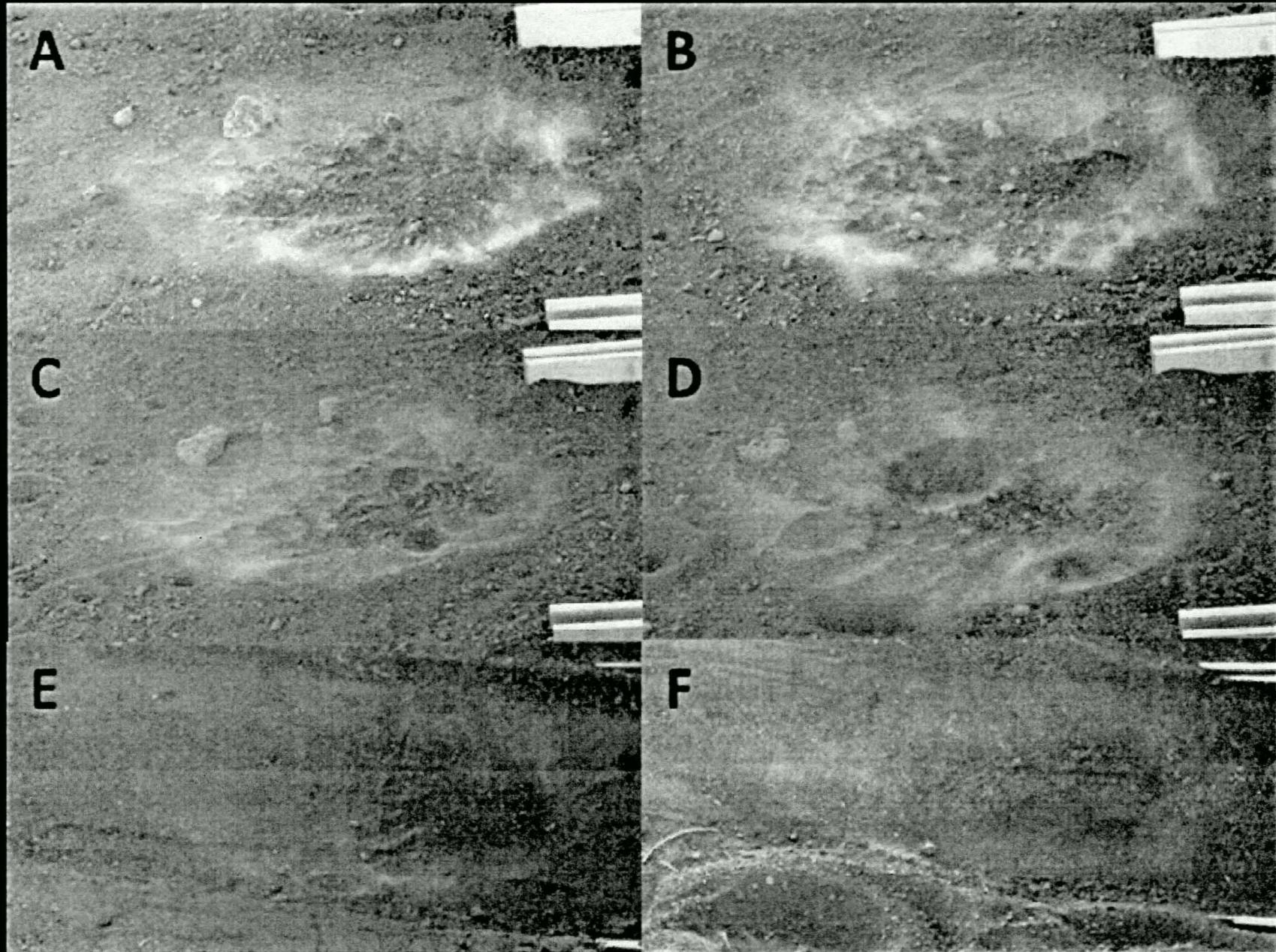
Rock exhumation

Lack of visible sand motion

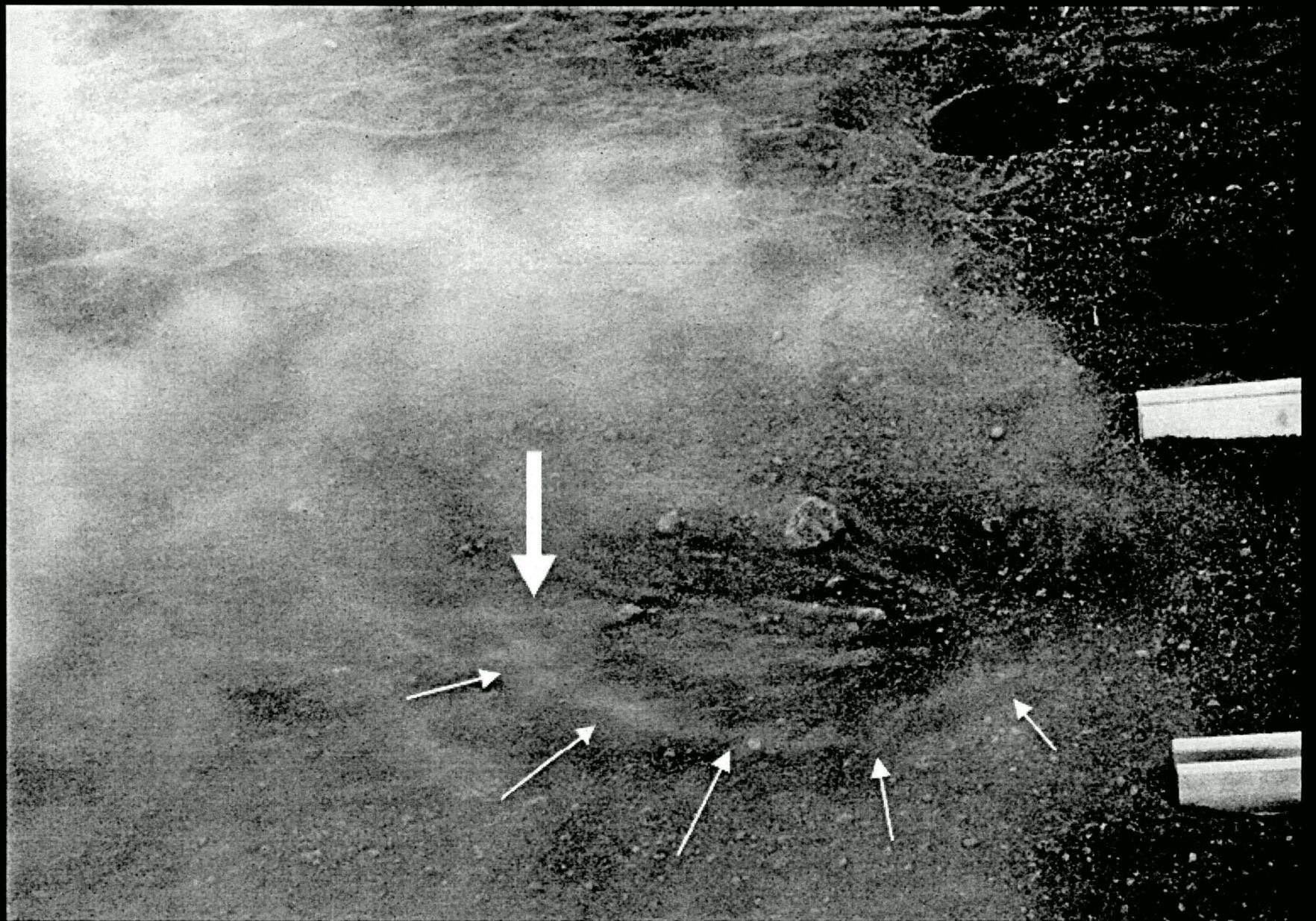
Don't Trust Your Eyes



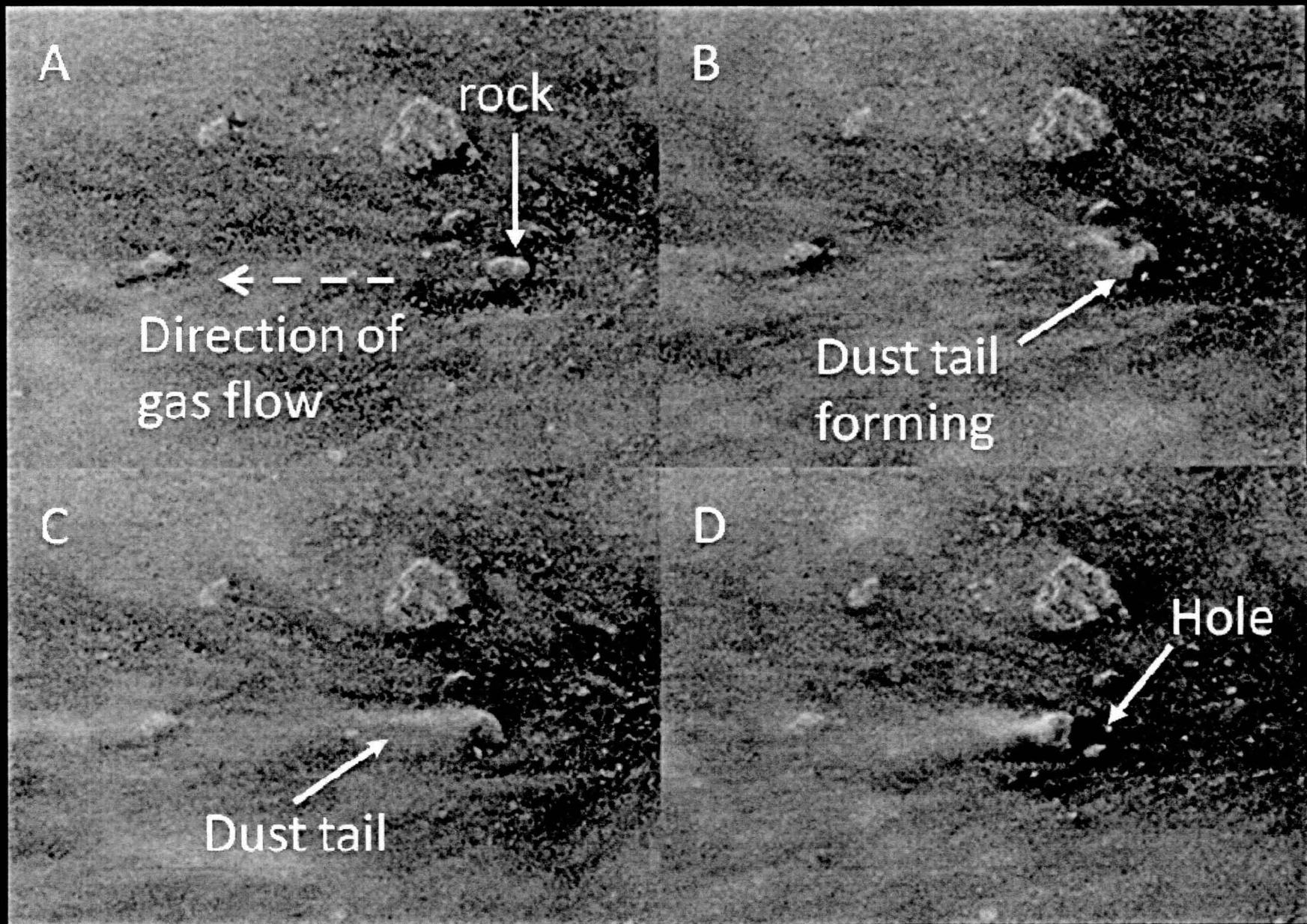
Transient Dust Rings



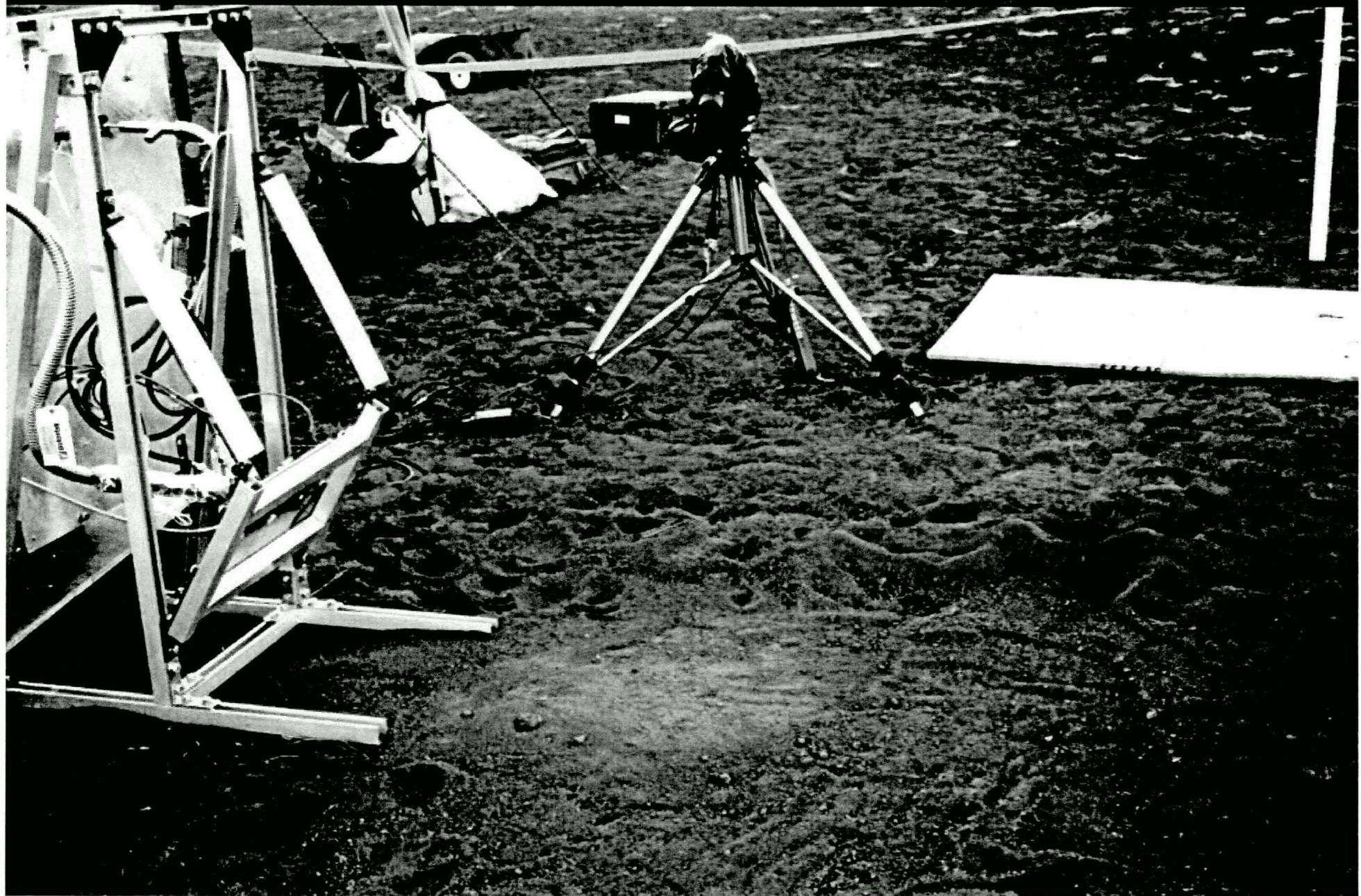
Arcs and Streaks



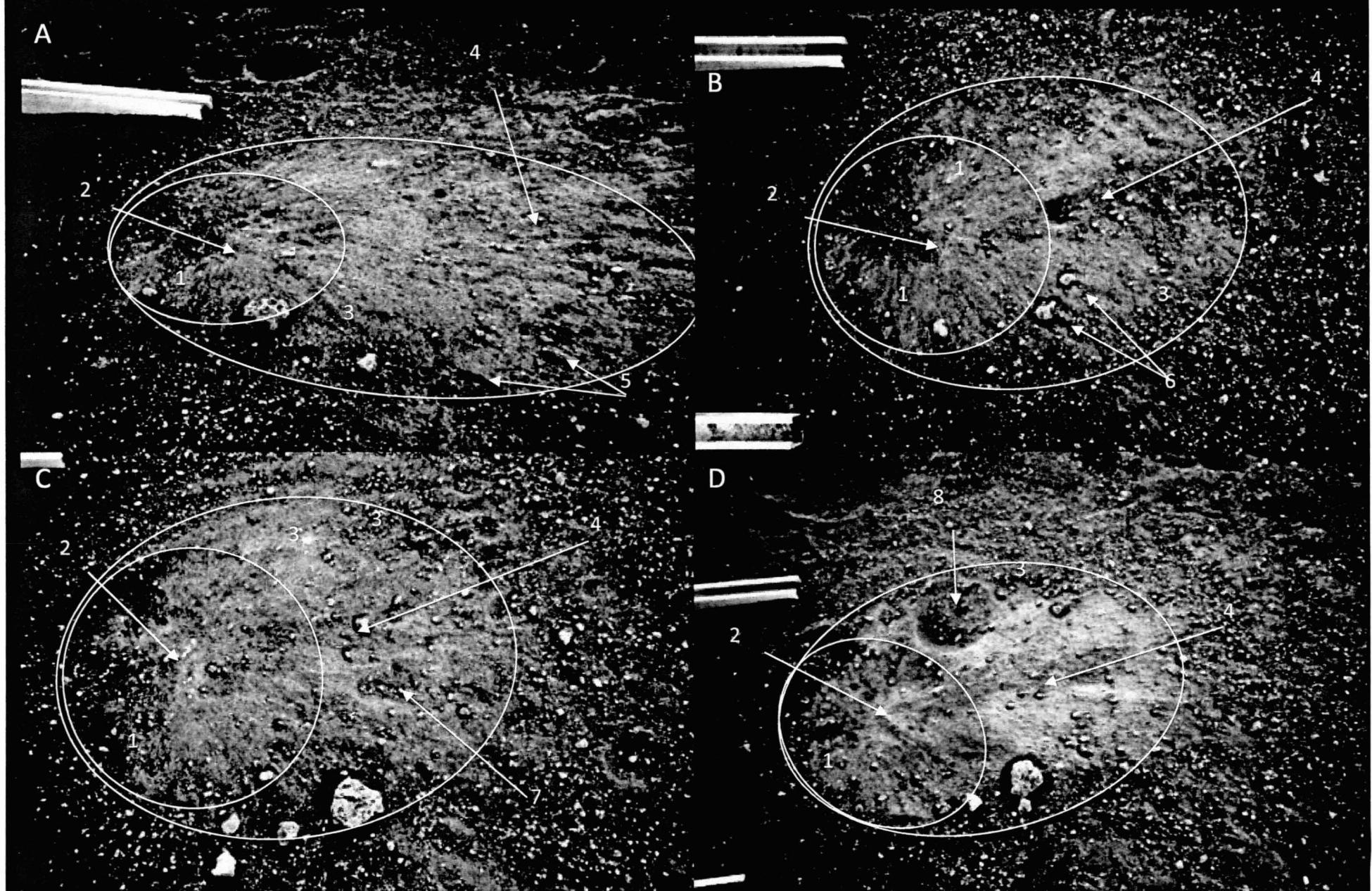
Streaks and Exhuming Rocks



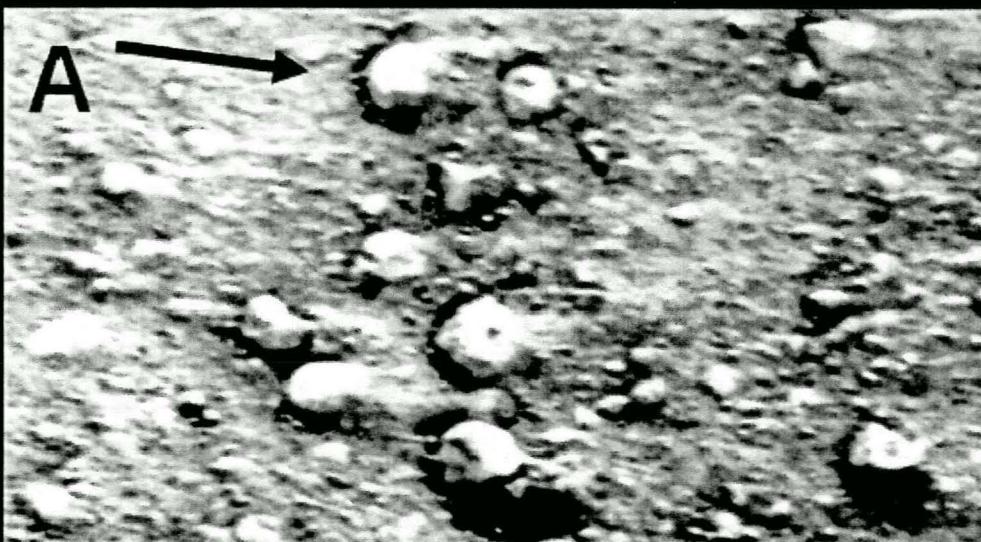
Surface Brightening



Bedforms from Plume Impingement



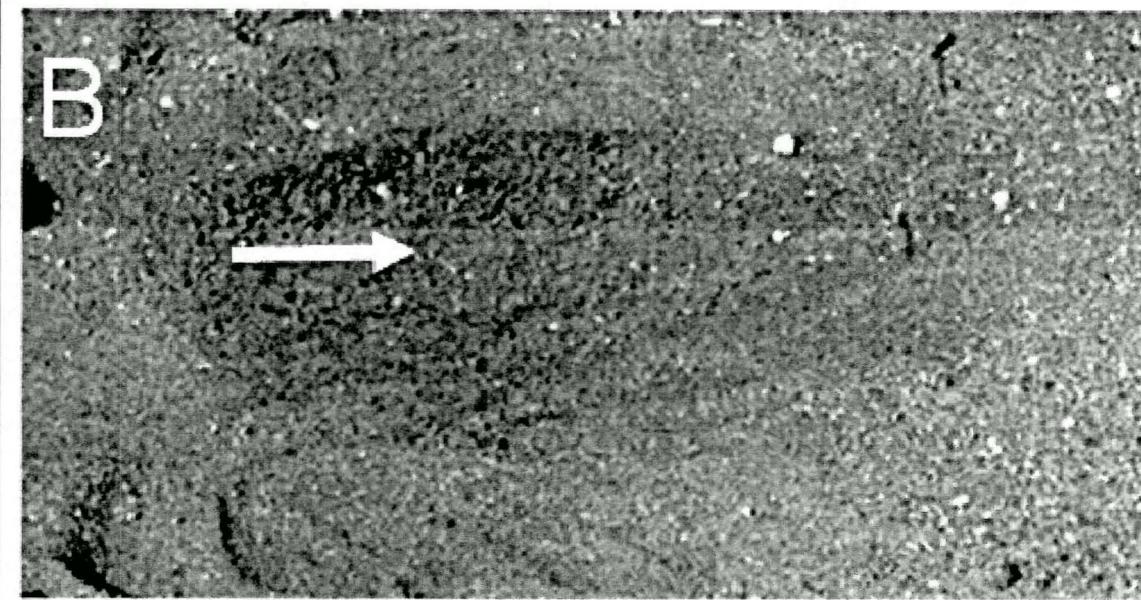
Scour Pools



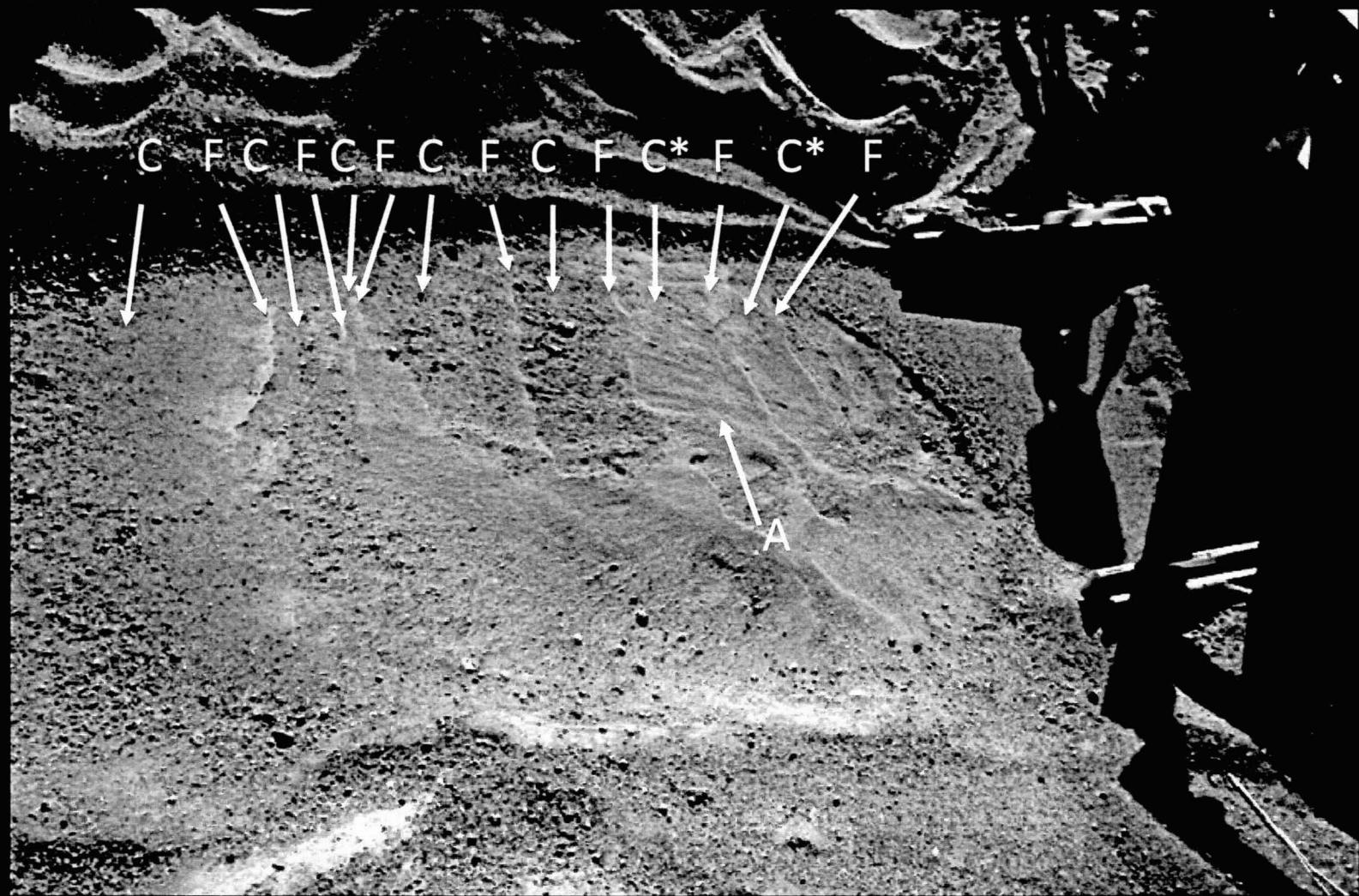
Dust Deposition on Small Length Scales



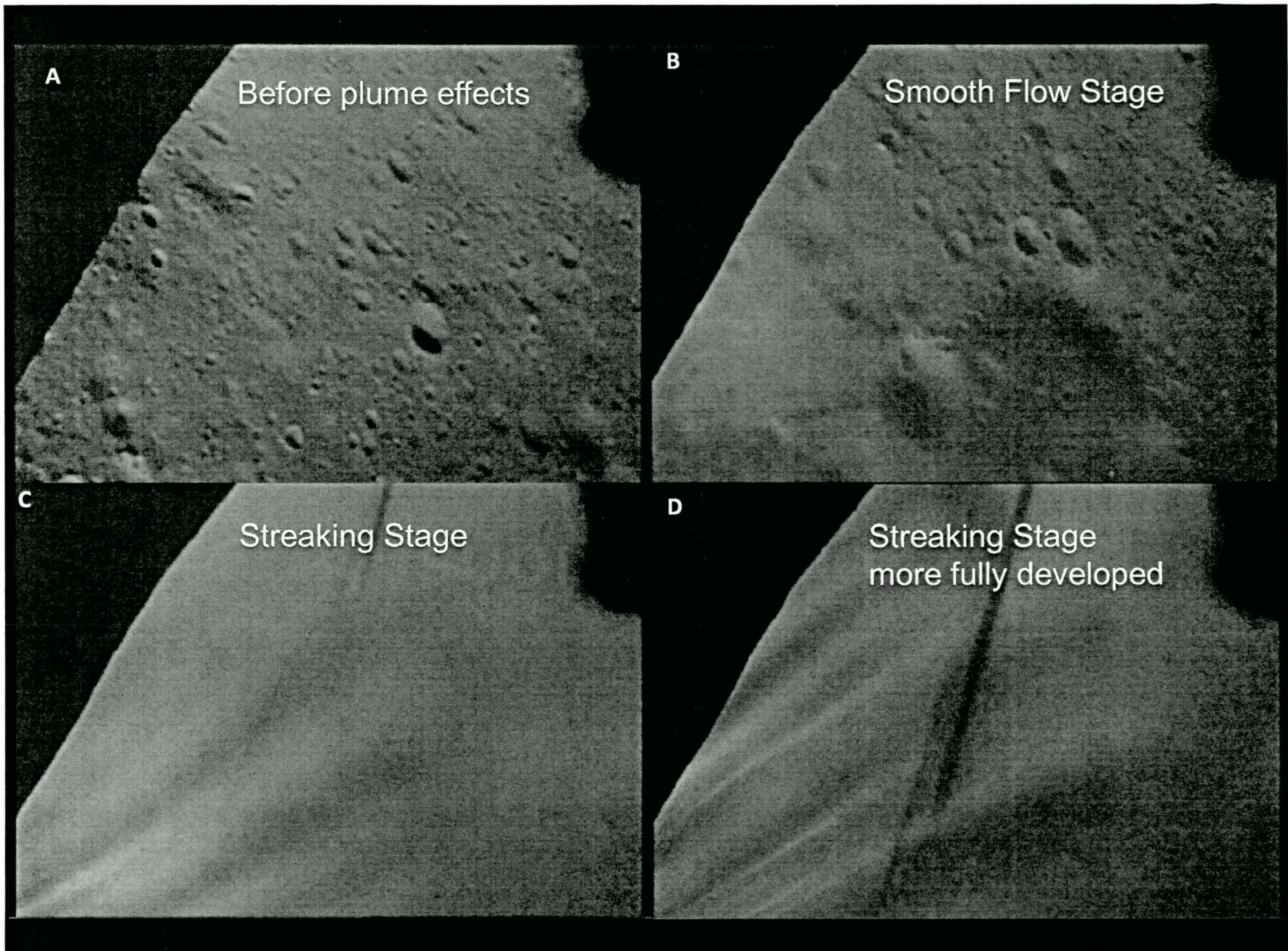
Cohesion: Absence of Dust Ring



Terraced Craters



Phenomenology in Apollo



E

Terrain Modification
Stage

F

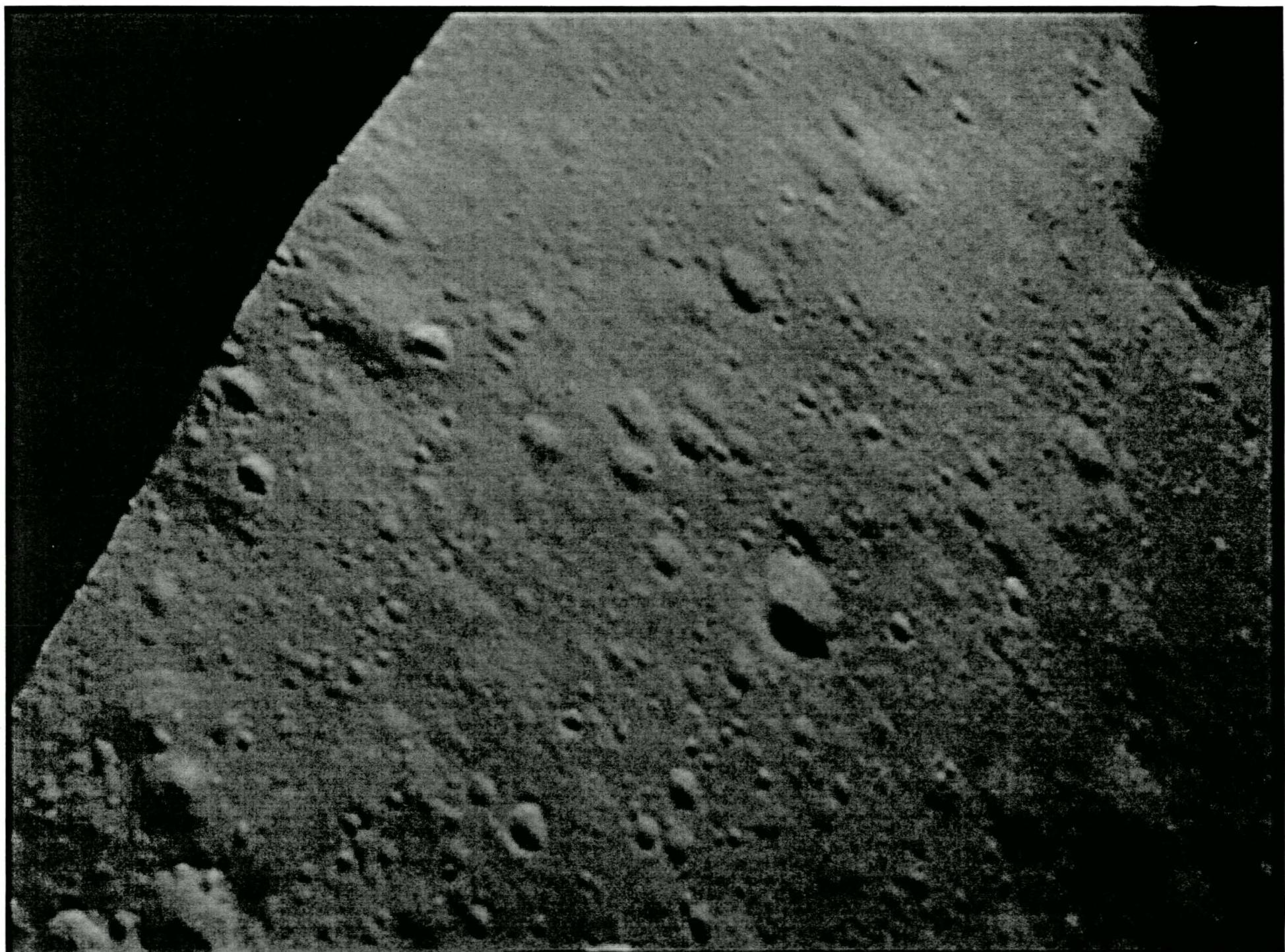
Terrain Modification
Stage

G

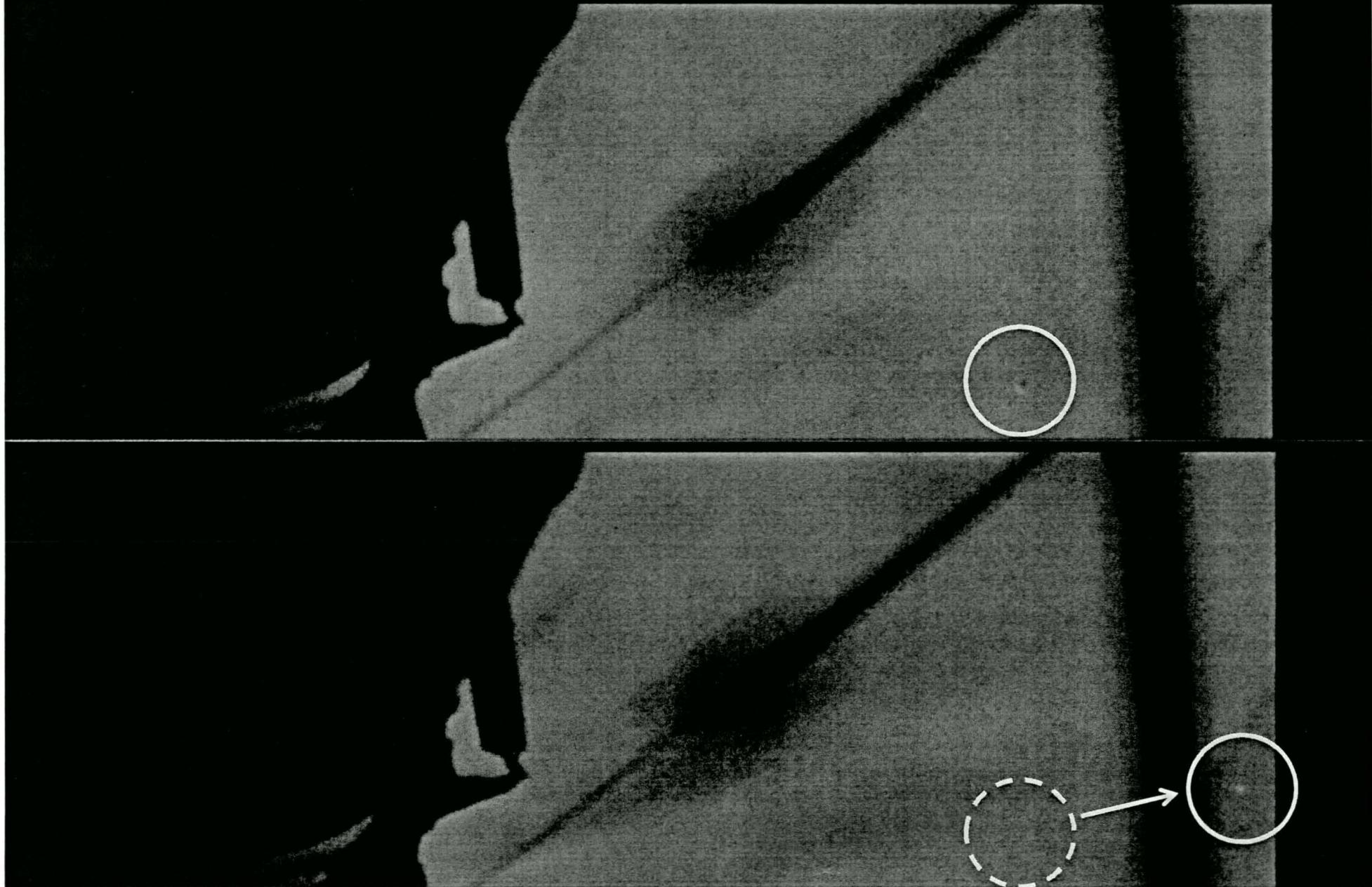
Clearing Stage

H

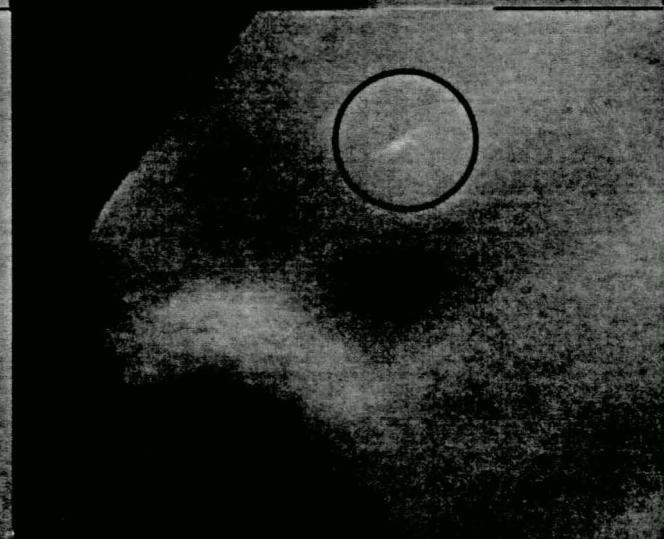
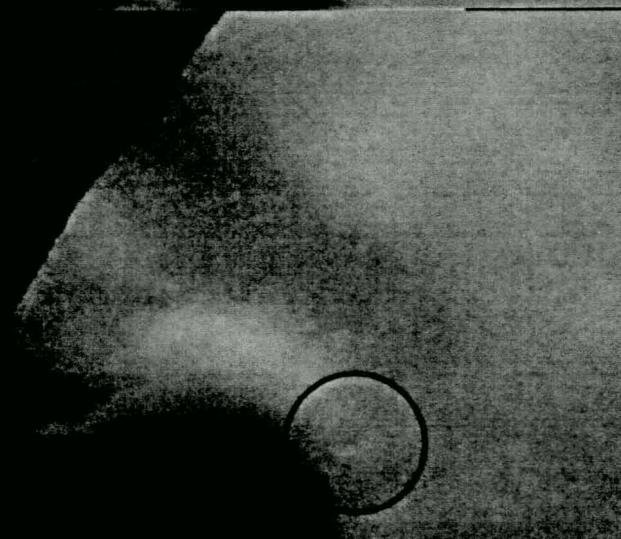
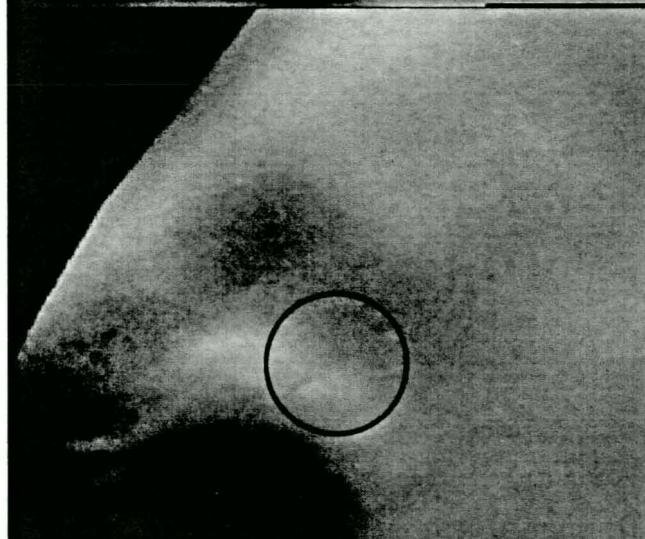
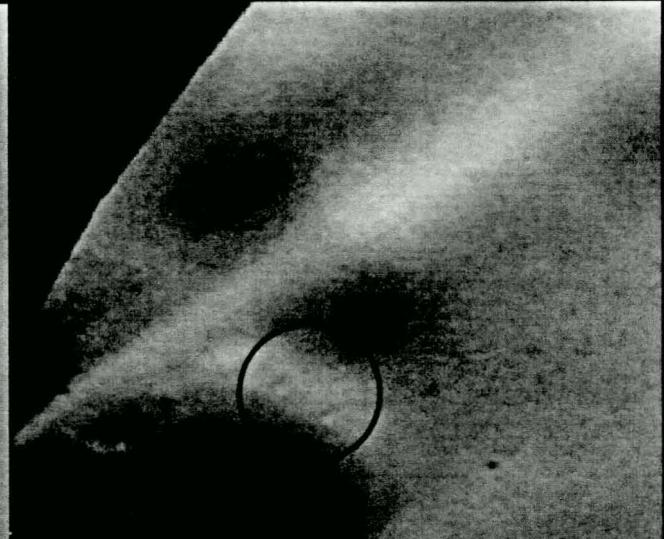
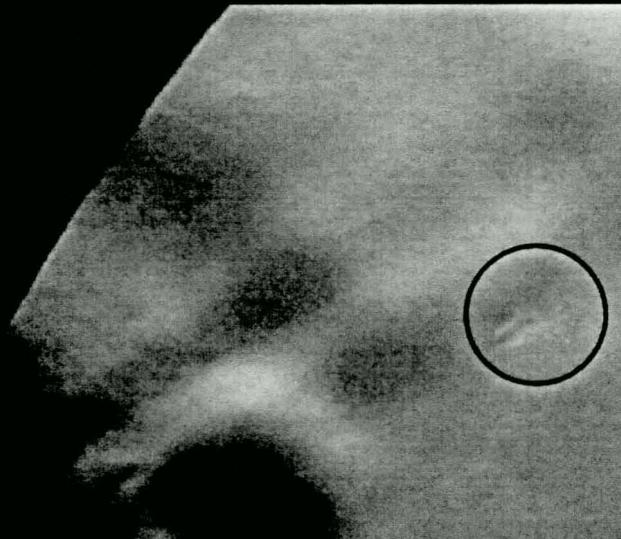
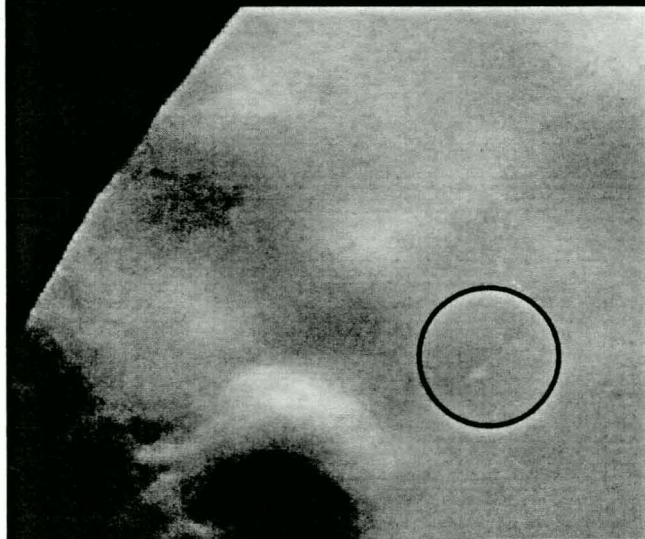
After plume effects



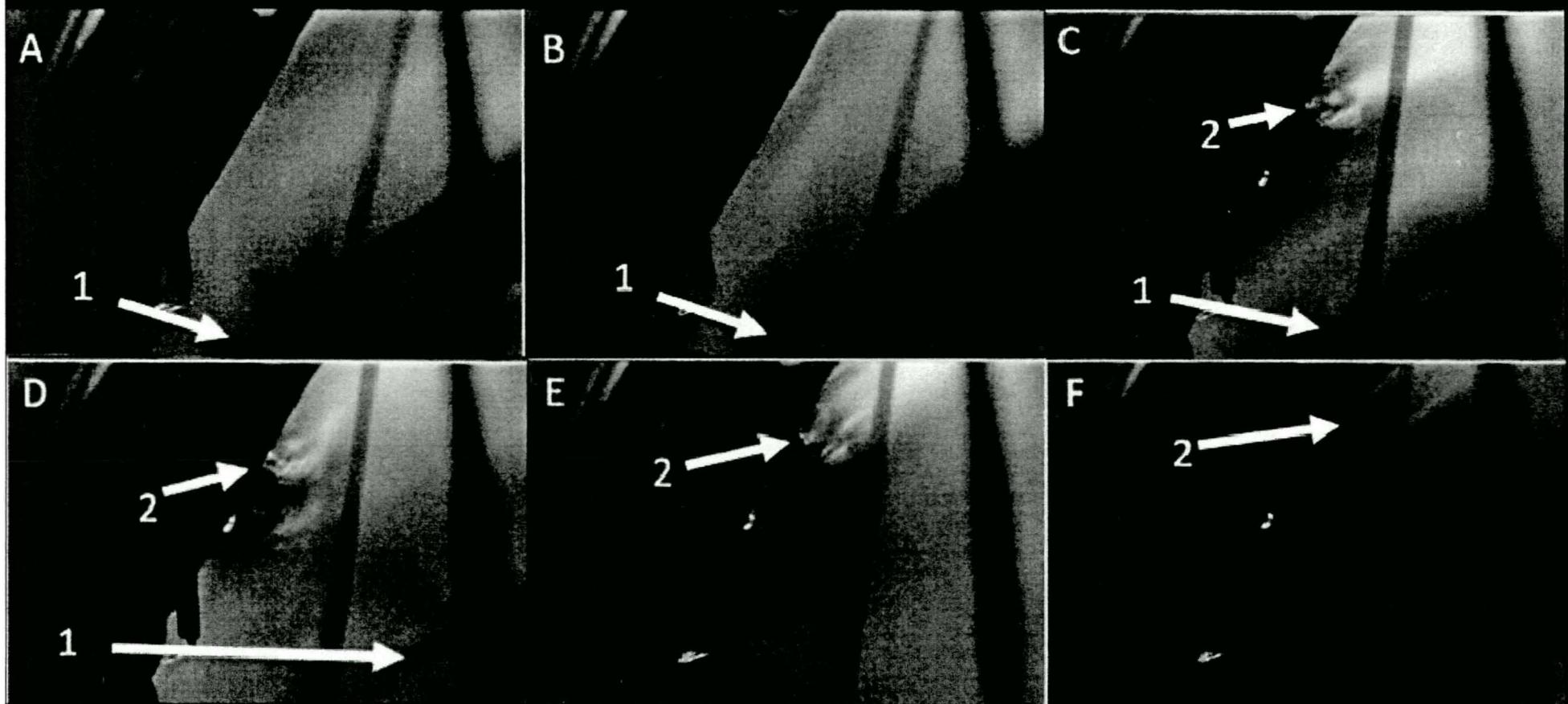
Rocks Blowing



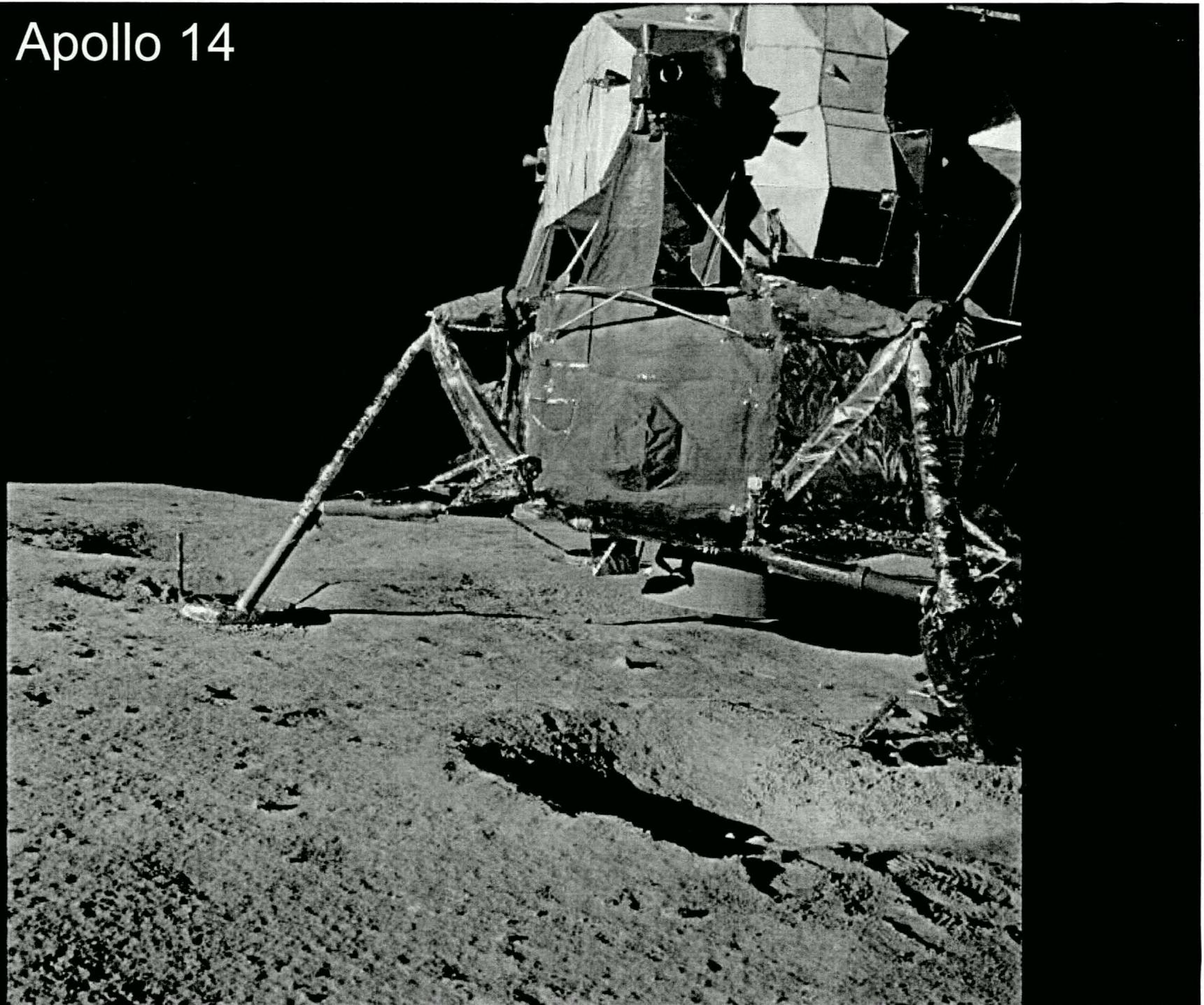
Dust Tails



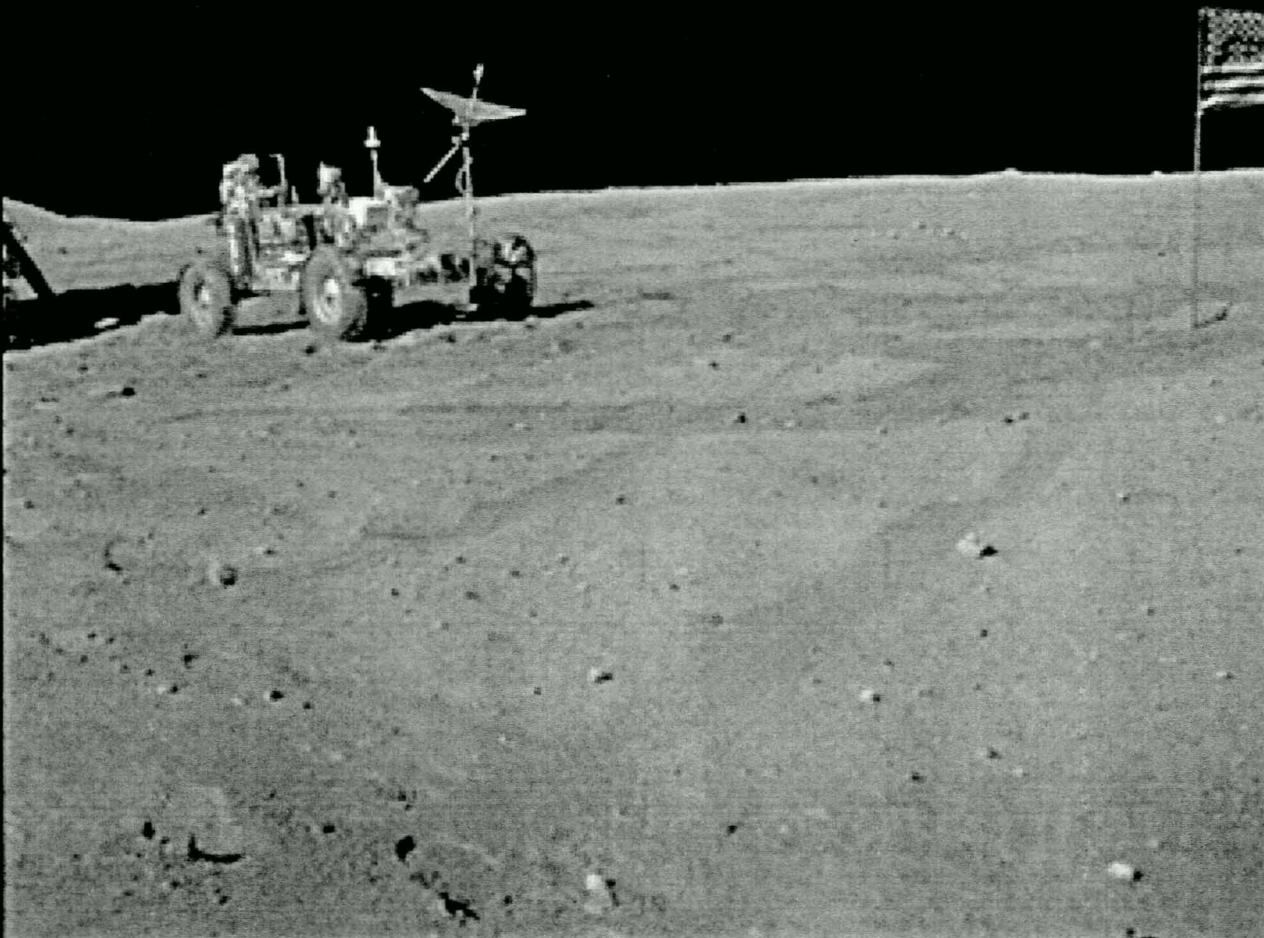
Terrain Modification



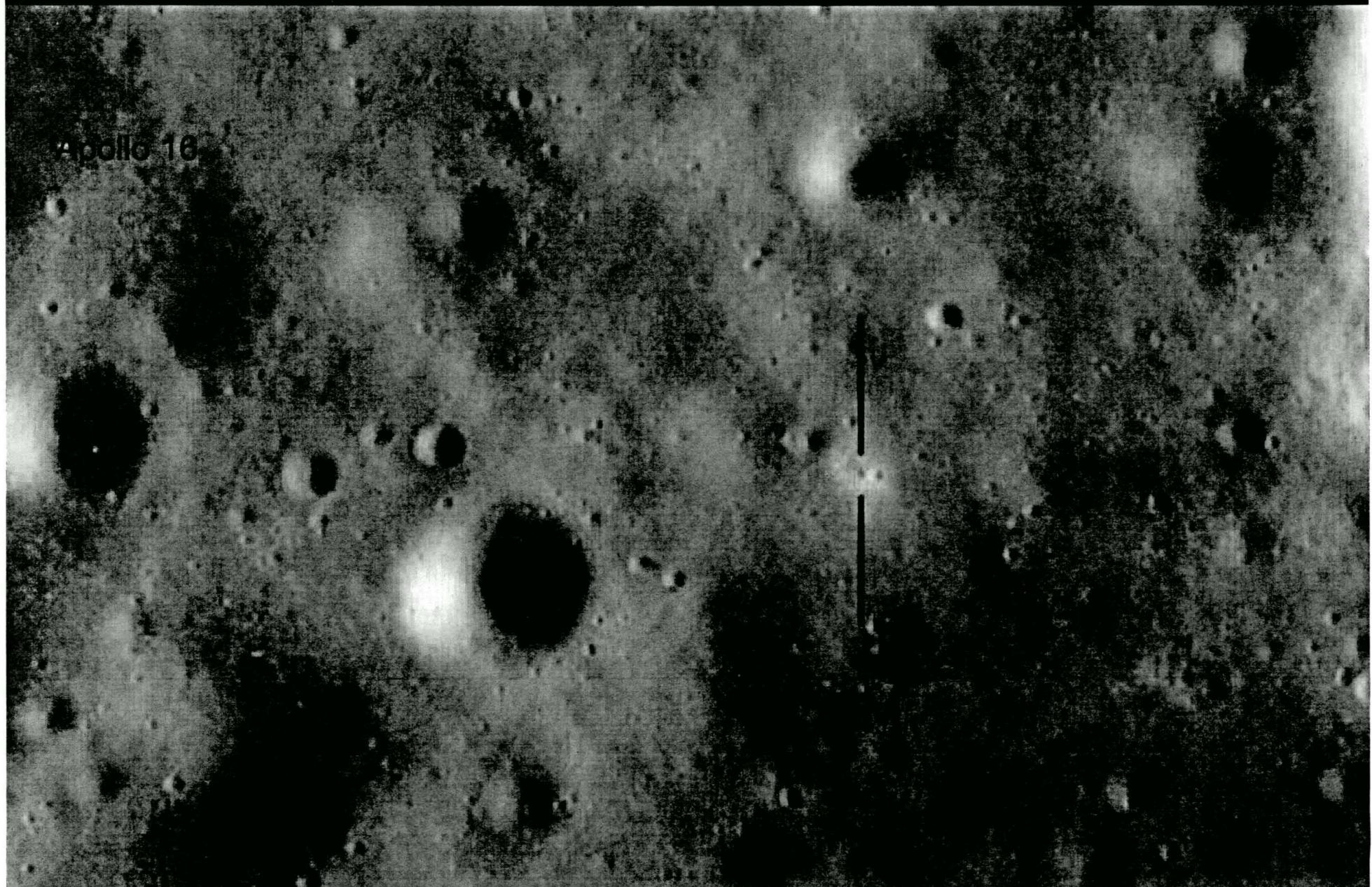
Apollo 14



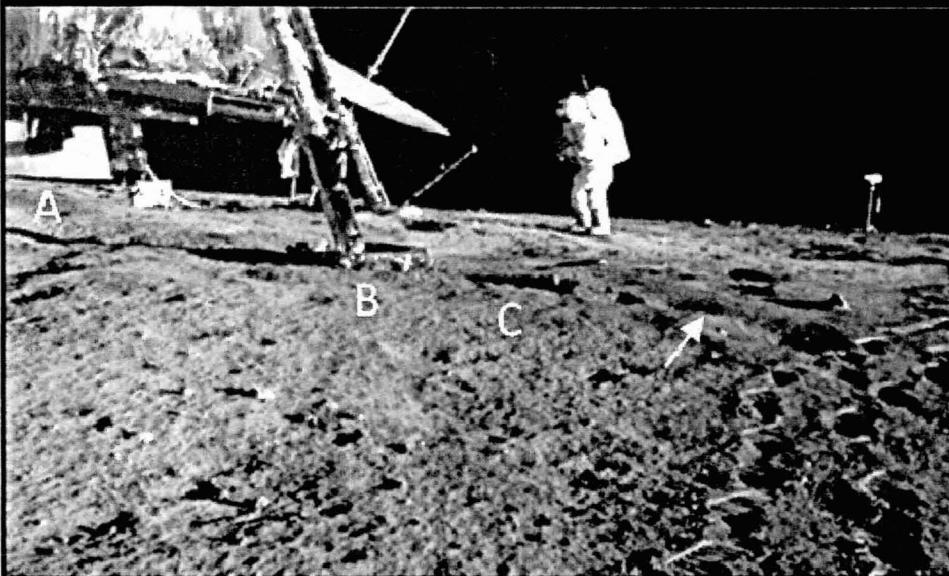
Brightened Soil at Landing Site

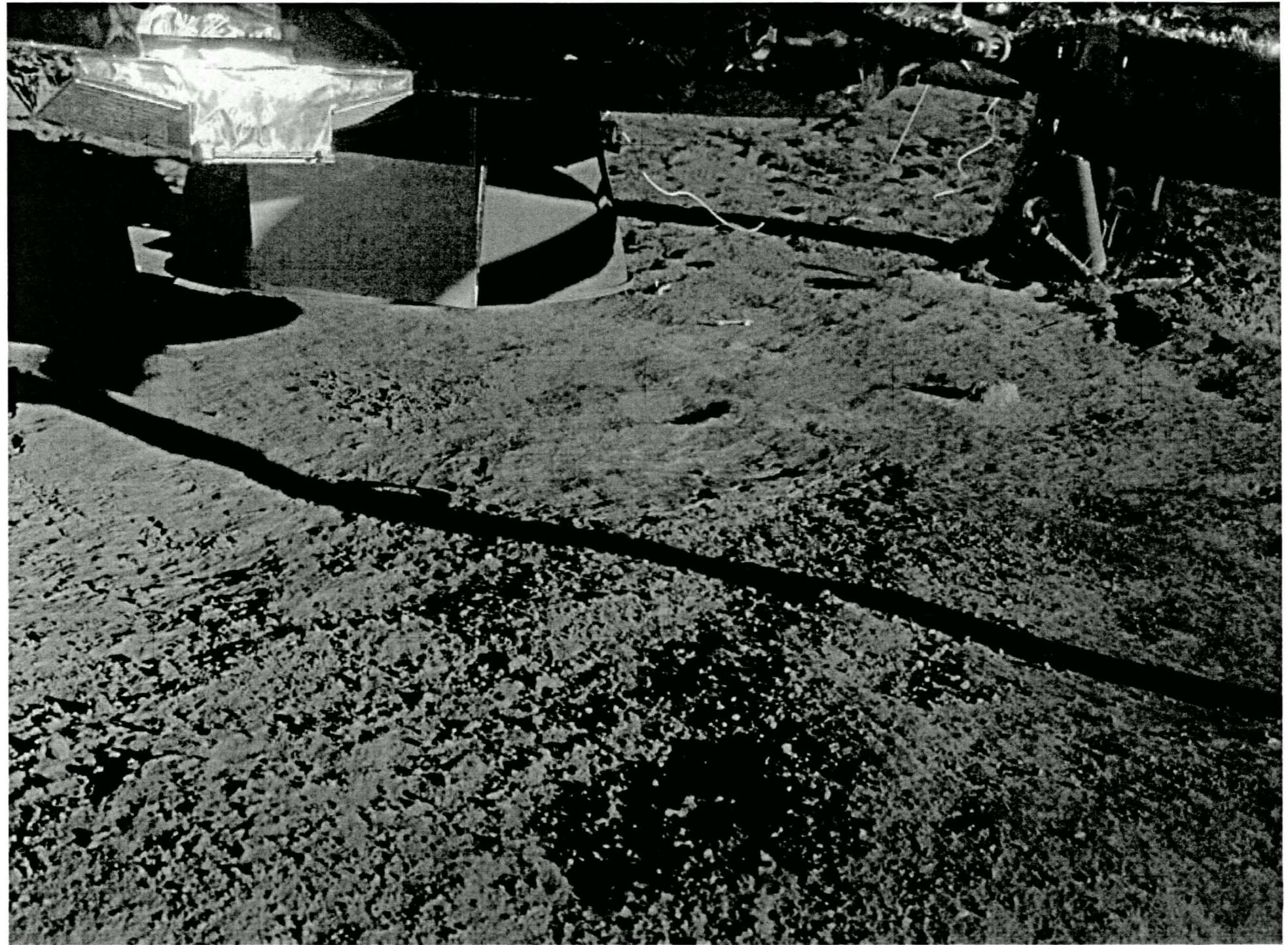


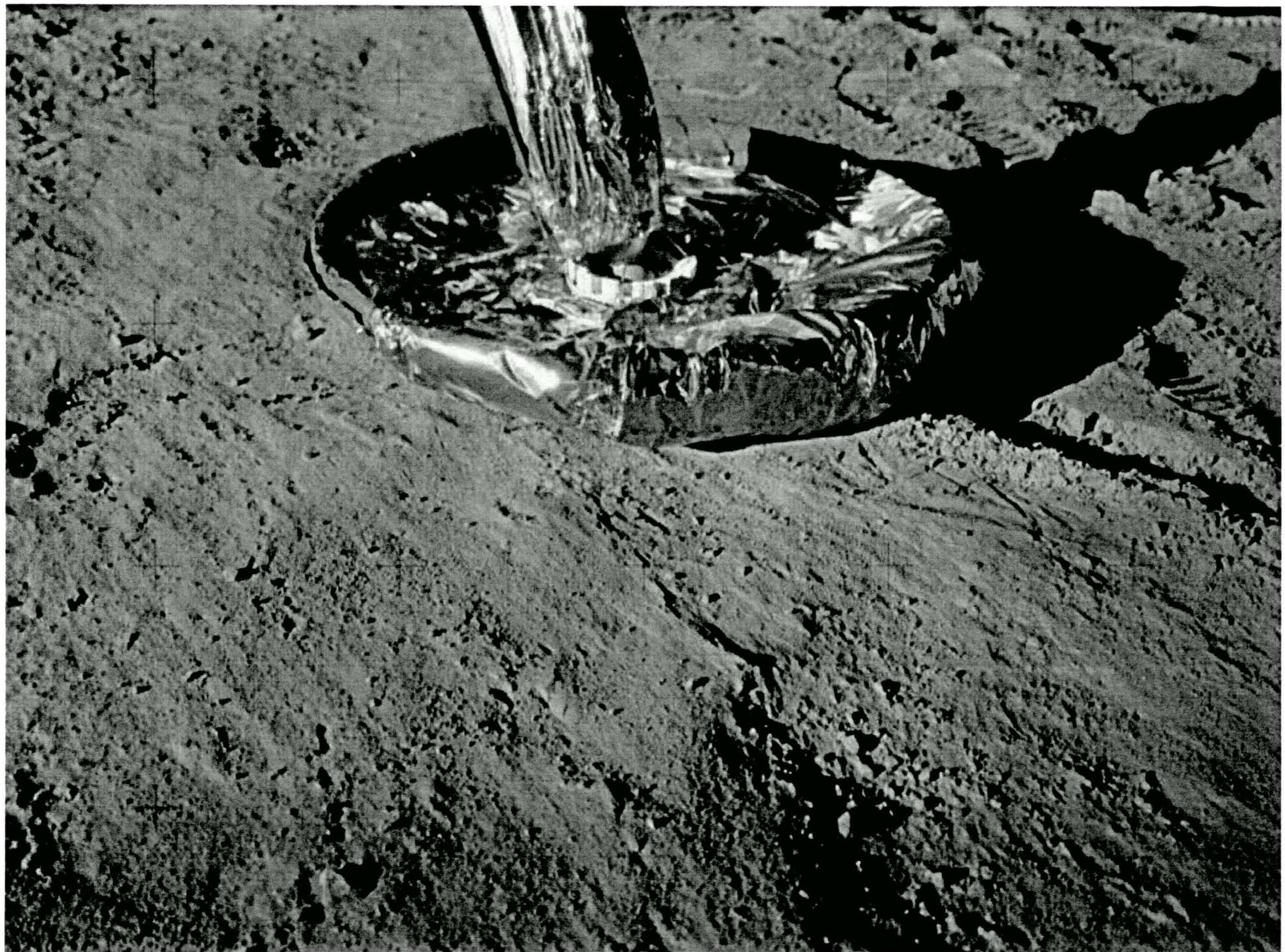
Surface Brightening of Landing Site

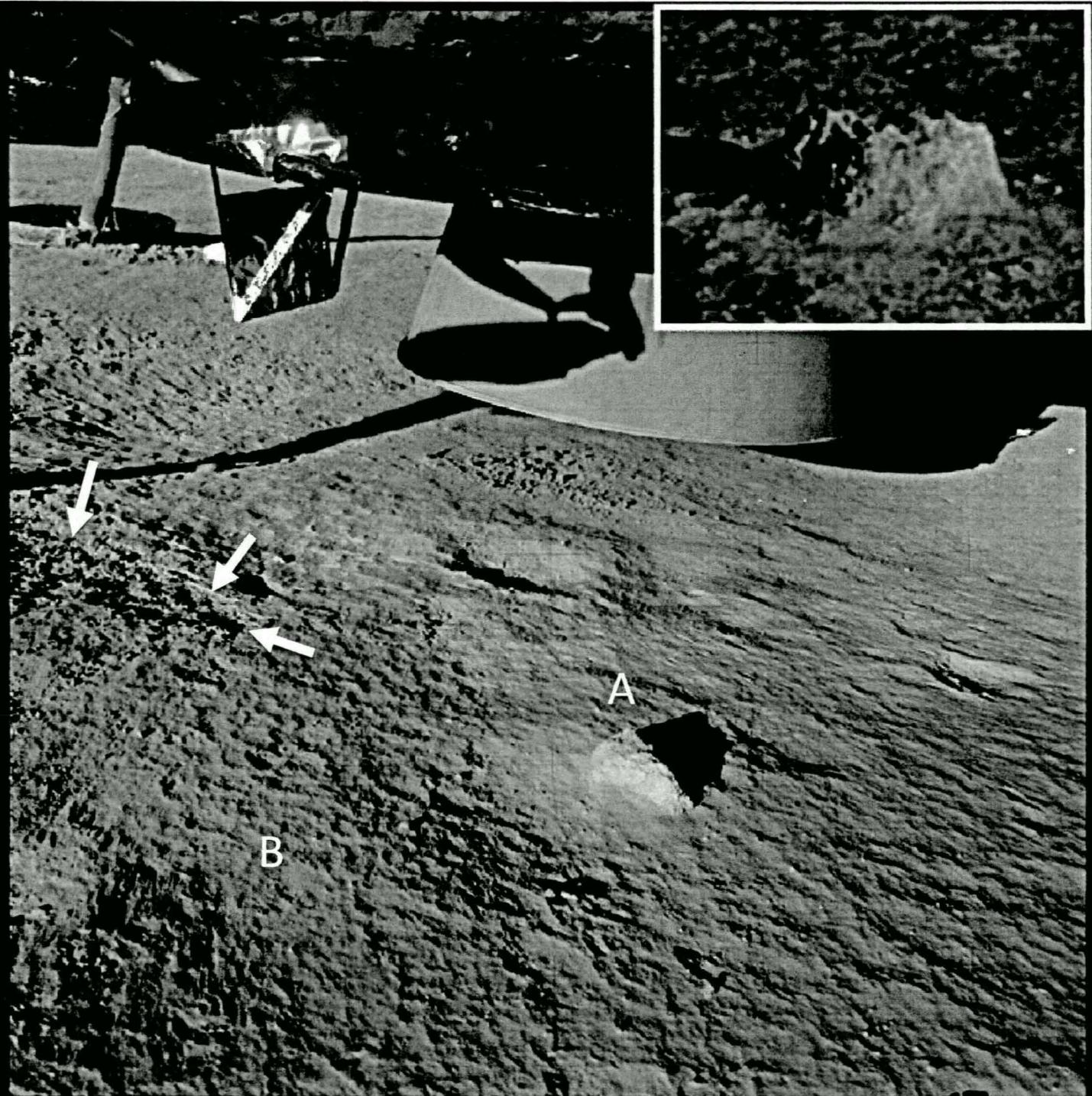


Rough Ejecta Ray





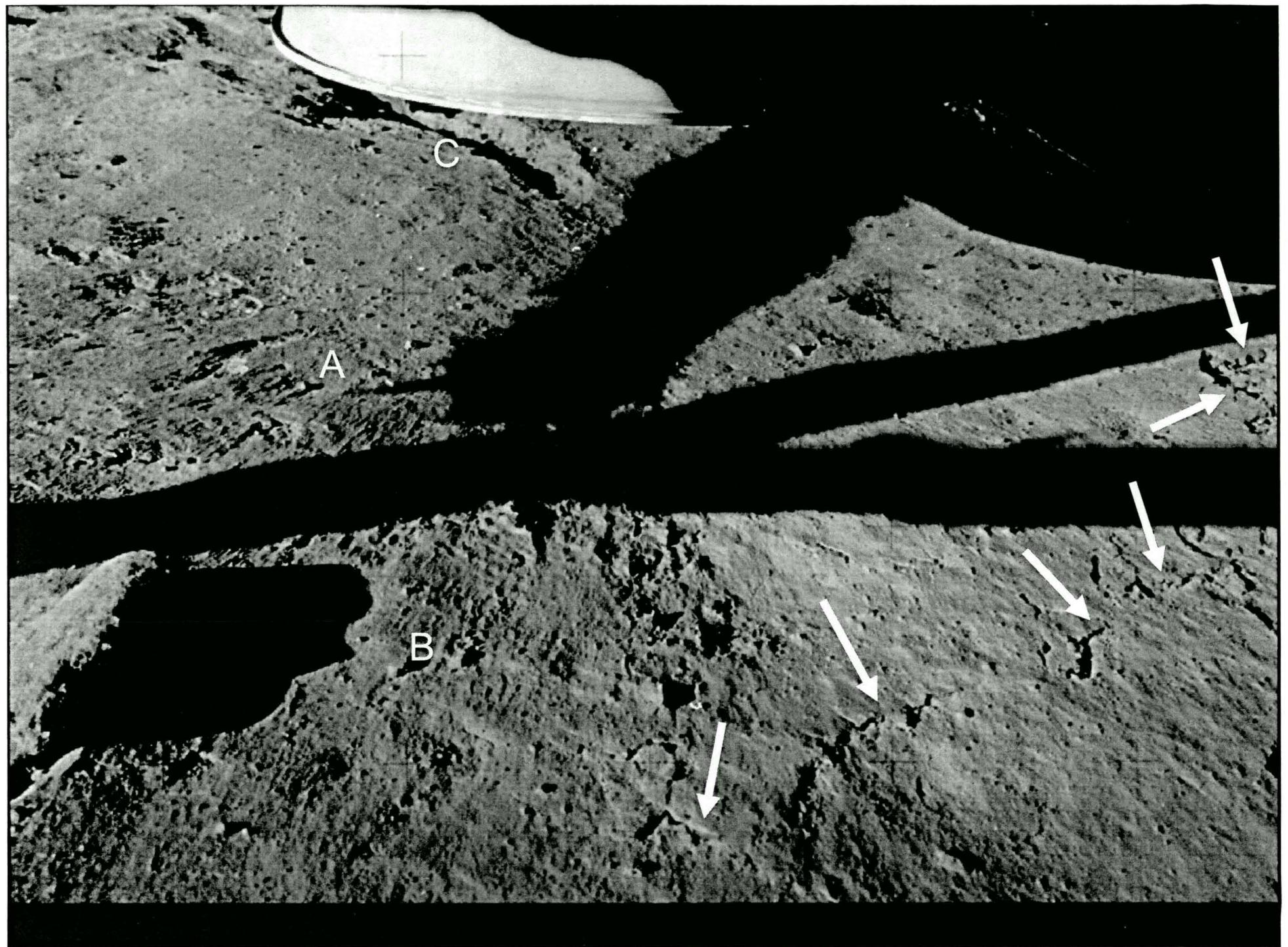




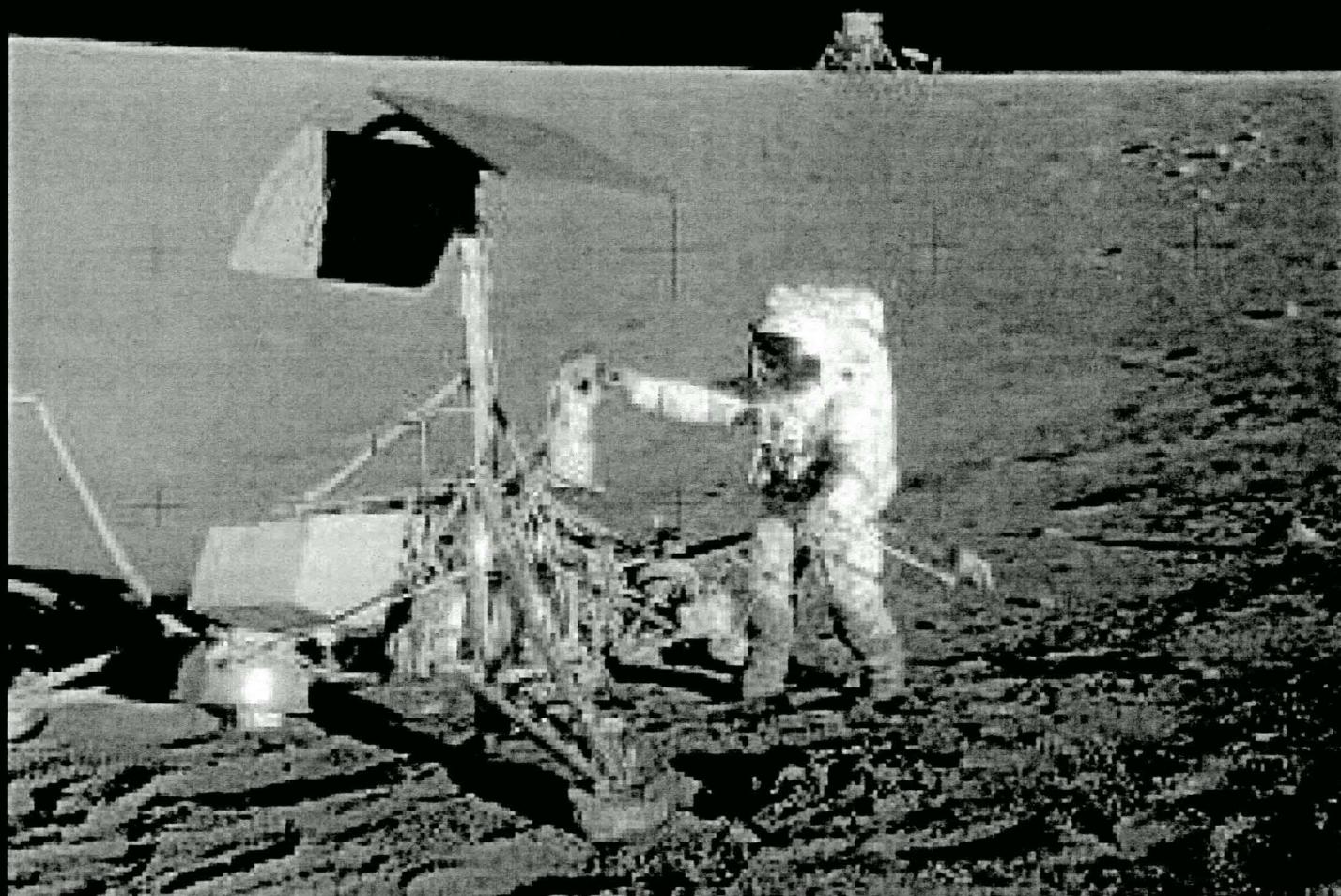
A

B

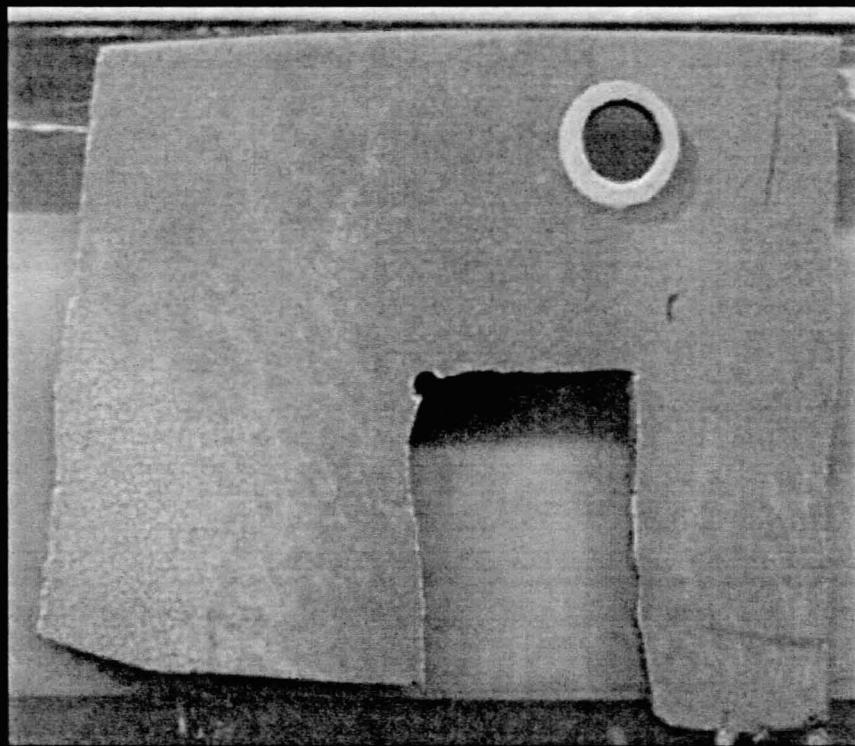
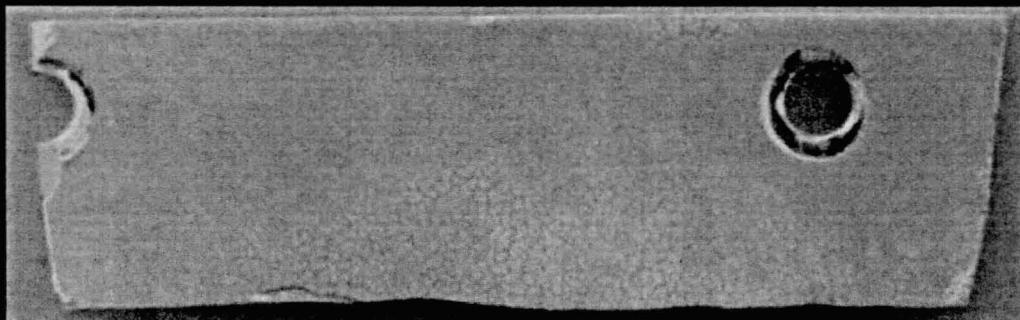




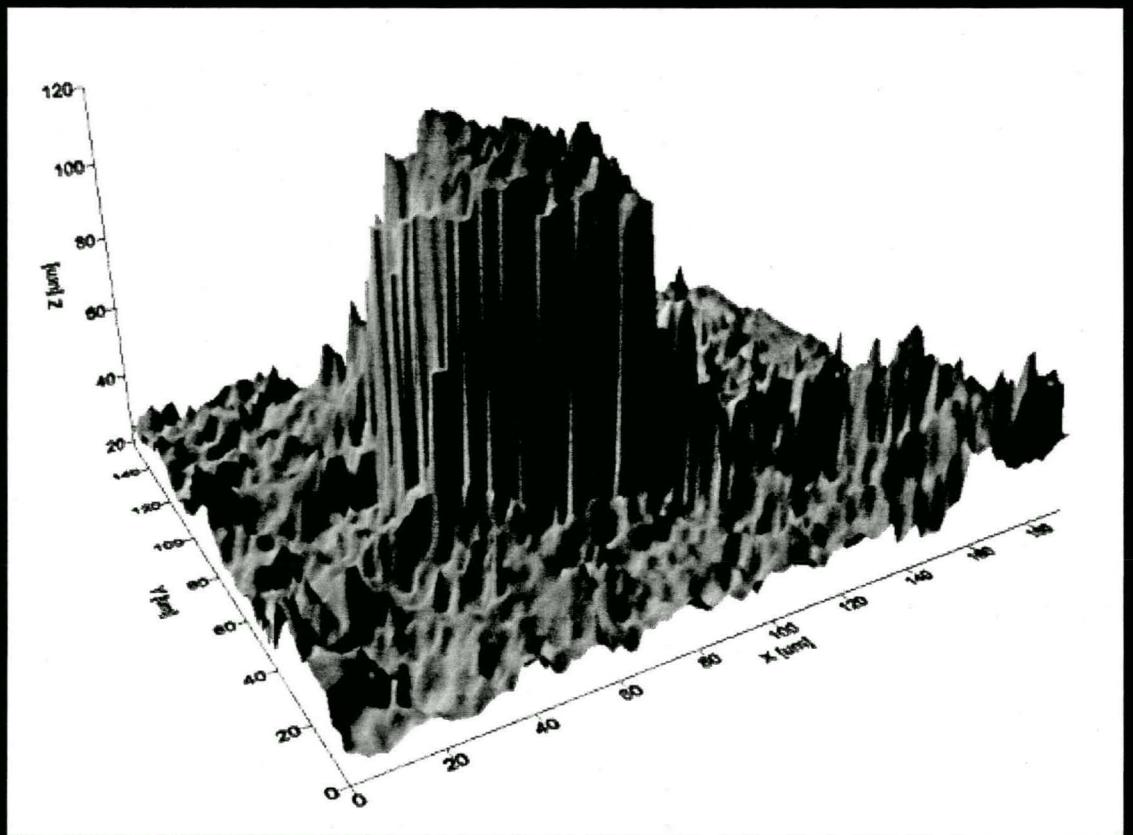
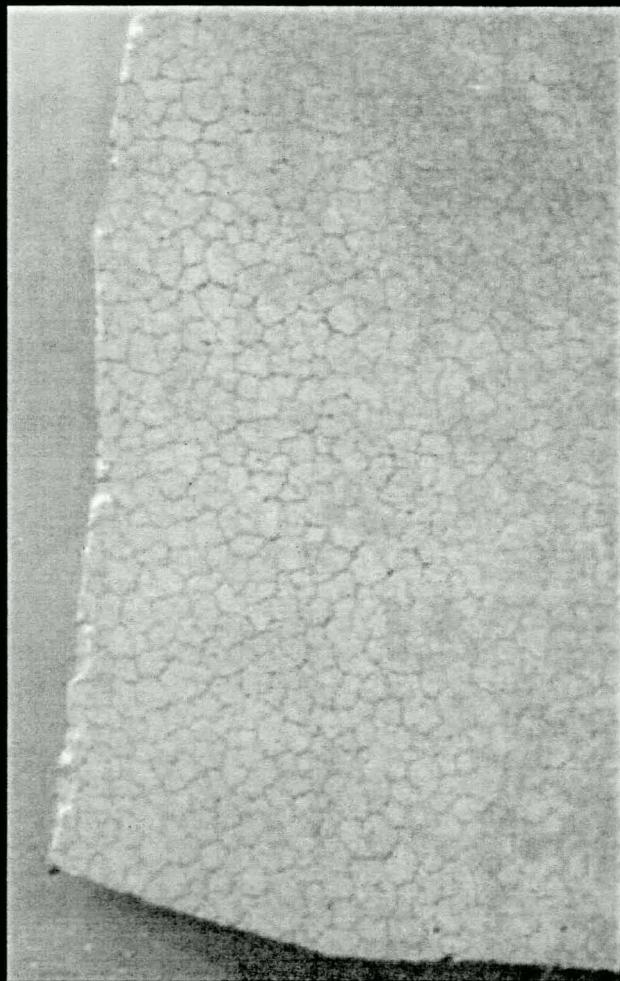
Surveyor III Coupons



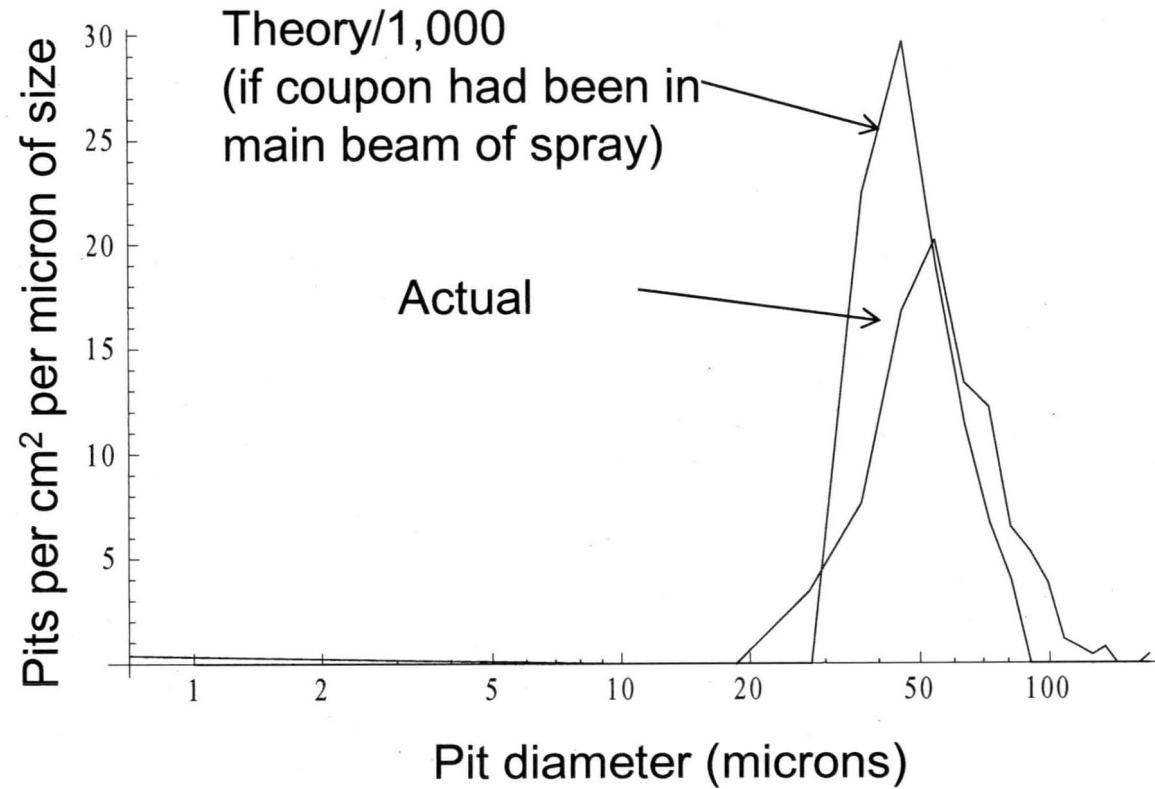
Surveyor III Coupons



Pits and Cracks



Comparison of Optical Density with Surveyor



- Surveyor shows 10^3 x fewer divots than if it were in main beam
- Surveyor show 34x less scouring than if it were main beam



What is Needed

What is Needed?

- A strategy to handle bulk soil failure
 - such as produces the terracing
- Rolling transport and effects on erosion rate
- Surface realism
- Layering of lunar soil
- Particle collisions
 - Momentum cascade
 - Scattering
 - Enhanced erosion and re-deposition